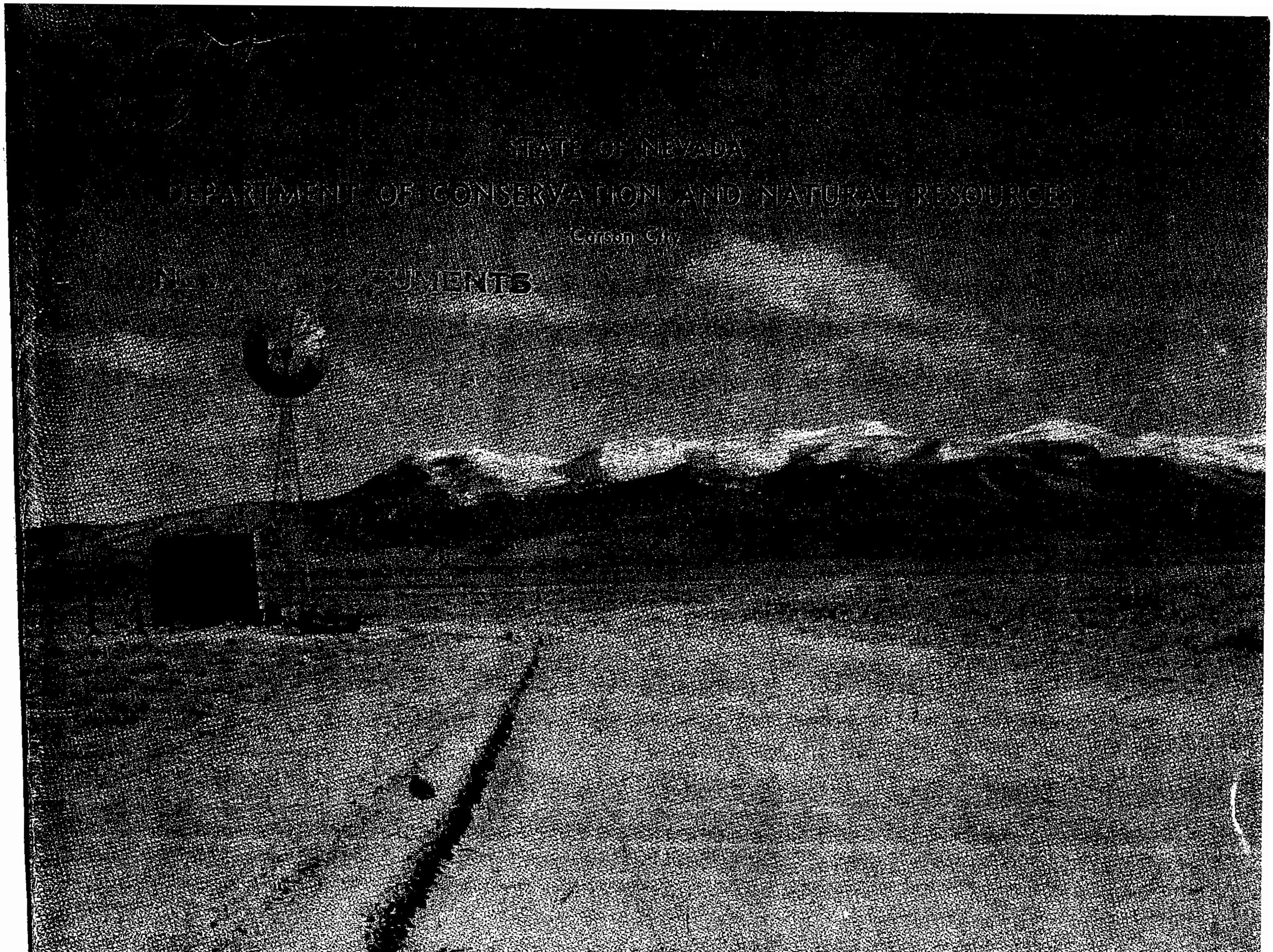
STATE OF NEVADA

DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES

Carson City



Long Valley—View of Well 20 58-8C2 and Buck Mountain

GROUND-WATER RESOURCES – RECONNAISSANCE SERIES

REPORT 3

GROUND–WATER APPRAISAL OF LONG VALLEY, WHITE PINE AND ELKO COUNTIES, NEVADA

By

THOMAS E. EAKIN

Geologist

Price $1.00

Prepared cooperatively by the
Geological Survey, U. S. Department of the Interior

JUNE 1961

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FOREWORD

The following report on a reconnaissance appraisal of the ground-water resources of Long Valley is the third in a series of such ground-water surveys authorized by the 1960 Legislature. The first of these reports, covering Newark Valley, was issued in December, 1960, and the second covering Pine Valley was issued in January, 1961. Similar reports on several additional areas will be issued this calendar year.

These reconnaissance ground-water surveys are conducted under a cooperative program between the State Department of Conservation and Natural Resources and the United States Geological Survey. They are designed to give information on the possibilities for developing ground-water in areas where such information is not available. They do not include areas covered, or planned to be covered, by surveys conducted under the regular ground-water program which has been carried on for the past several years in cooperation with the United States Geological Survey.

These reports give valuable information to land administering agencies as well as to prospective land developers.

Hugh A. Shamberger, Director,
Department of Conservation and Natural Resources

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GROUND-WATER APPRAISAL OF LONG VALLEY, WHITE PINE AND ELKO COUNTIES, NEVADA

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SUMMARY

The results of this reconnaissance indicate that the average annual ground-water recharge in Long Valley is on the order of 10,000 acre-feet. This amount seems to be generally compatible with estimates of recharge for other valleys of eastern Nevada, if consideration is given to differences of area, climate, topography, geology, and vegetation.

A direct estimate of the total ground-water discharge from Long Valley could not be made because of an unusual condition involving the discharge of ground water from the valley fill through bedrock and out of the drainage basin. On the basis of limited information, it is postulated that the ground water discharging into the bedrock probably is moving southward in the direction of White River Valley. The magnitude of this discharge apparently is on the order of 8,000 acre-feet a year, based on the difference between the estimated ground-water recharge of 10,000 acre-feet and the estimated discharge of 2,000 acre-feet from the valley fill by transpiration of phreatophytes and evaporation. Any errors in the estimates of recharge and discharge are included in the estimate of discharge through the bedrock.

Ground water in storage is estimated to be about 9,000 acre-feet per foot of saturated thickness of valley fill enclosed by the 6,200-foot topographic contour. The relatively large volume of ground water in storage provides a substantial reserve for maintaining potential pumping requirements during protracted periods of drought.

The minimum estimate of perennial yield is about 2,000 acre-feet a year, based principally on the salvage of discharge by evapotranspiration. Whether the yield could be increased by salvage of subsurface outflow from the valley is not known. However the physical conditions of the discharge through bedrock are believed to be such that withdrawals by wells would have little effect on the quantity of that discharge unless wells could be placed to intercept a part of the discharge or until a large fraction of the ground water in storage in the valley fill was removed. This is unlikely, as it would involve pumping lifts substantially greater than the probable present-day economic limits for lifting water for irrigation.

Locally, the chemical quality of the ground water may not be suitable for irrigation. Additionally, the growing season apparently is short.

The more favorable areas for initial prospecting for moderate to large ground-water supplies appear to be in the lower parts of the alluvial apron along the east and west sides of the valley, principally in Tps. 21 to 23 N. However, the nonpumping depth to water may be 100 feet or more in parts of these areas.

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INTRODUCTION

The development of ground water in Nevada has shown a substantial increase in recent years. A part of this increase is due to the effort to bring new land into cultivation. The increasing interest in ground-water development has created a substantial demand for information on ground-water resources throughout the State.

Recognizing this need, the State Legislators enacted special legislation (Chapt. 181, Stats. 1960) for beginning a series of reconnaissance studies of the ground-water resources of Nevada. As provided in the legislation, these studies are being made by the U. S. Geological Survey in cooperation with the Nevada Department of Conservation and Natural Resources.

Interest in ground-water resources currently includes many areas and is extending to additional areas almost continuously. Thus, the emphasis of the studies under this special legislation is to provide a general appraisal of the ground-water resources in particular valleys or areas where information is urgently needed, as quickly as possible. For this reason each reconnaissance study is limited severly in time, field work for each area generally averaging about two weeks.

Additionally, the Department of Conservation and Natural Resources has established a special report series to expedite publication of the results of these reconnaissance studies. Figure 1 shows the areas for which reports have been published in this series. The present report is the third in the reconnaissance series. It describes the physical conditions of Long Valley and includes observations of the interrelation of climate, geology, and hydrology as they affect ground-water resources. It includes also a preliminary estimate of the average annual recharge to and discharge from the ground-water reservoir.

The investigation was made under the administrative supervision of Omar J. Loeltz, district engineer in charge of ground-water studies in Nevada. The writer wishes to acknowledge his appreciation to personnel of the district office for constructive discussions and review, relative to this report, all of which have been most helpful.

Appreciation also is expressed for well data supplied by C. T. Snyder, which were obtained in connection with the soil and moisture conservation program of the branch of general hydrology, U. S. Geological Survey.

Location and General Features

Long Valley, in east-central Nevada, lies within an area enclosed by lat 39° 23' and 40° 12' N., and long 115° 10' and 115° 35' W. It is principally in northwestern White Pine County but its northern end extends a few miles into Elko County.

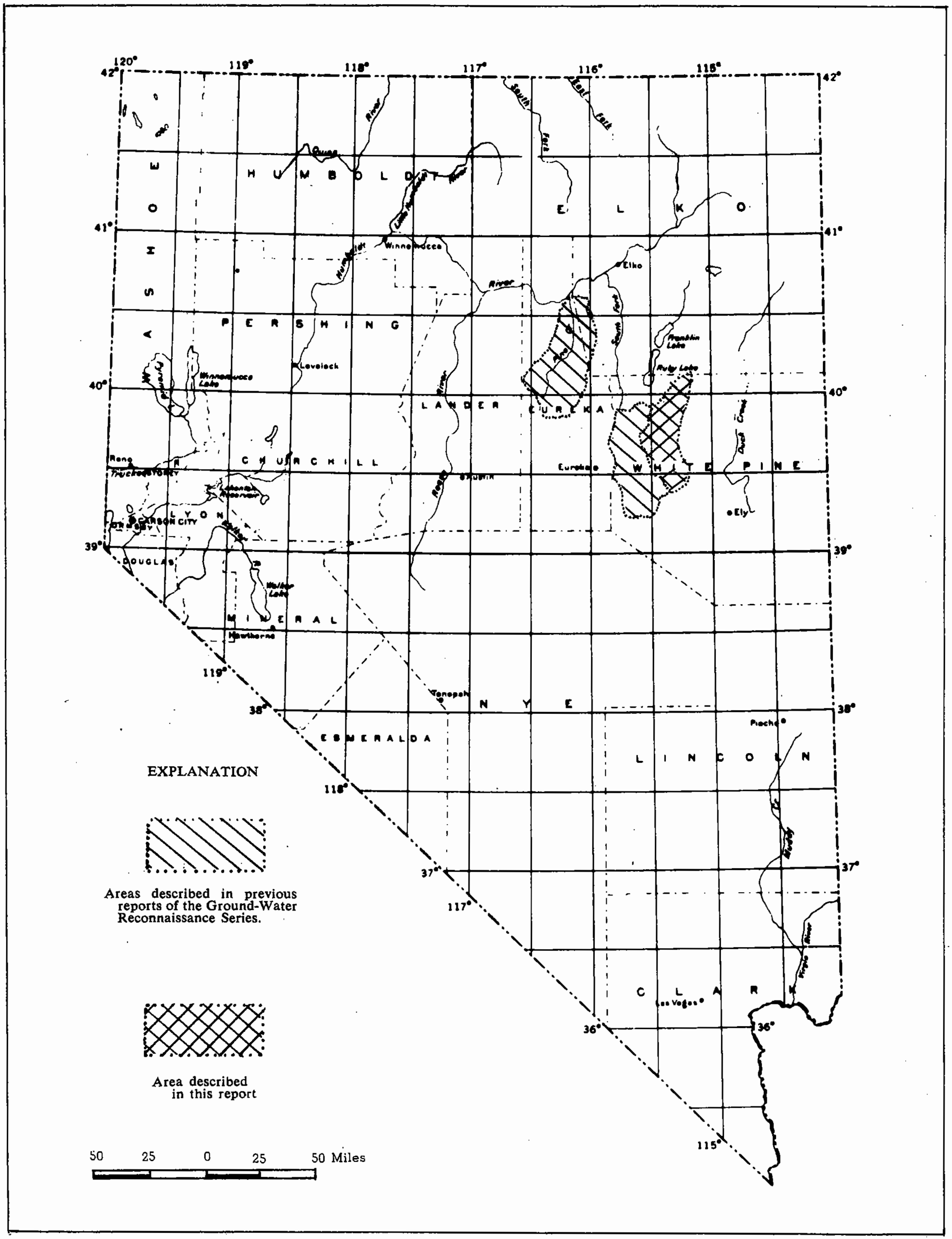

Figure 1.—Map of Nevada showing areas described in previous reports of the Ground-Water Reconnaissance Series and in this report.

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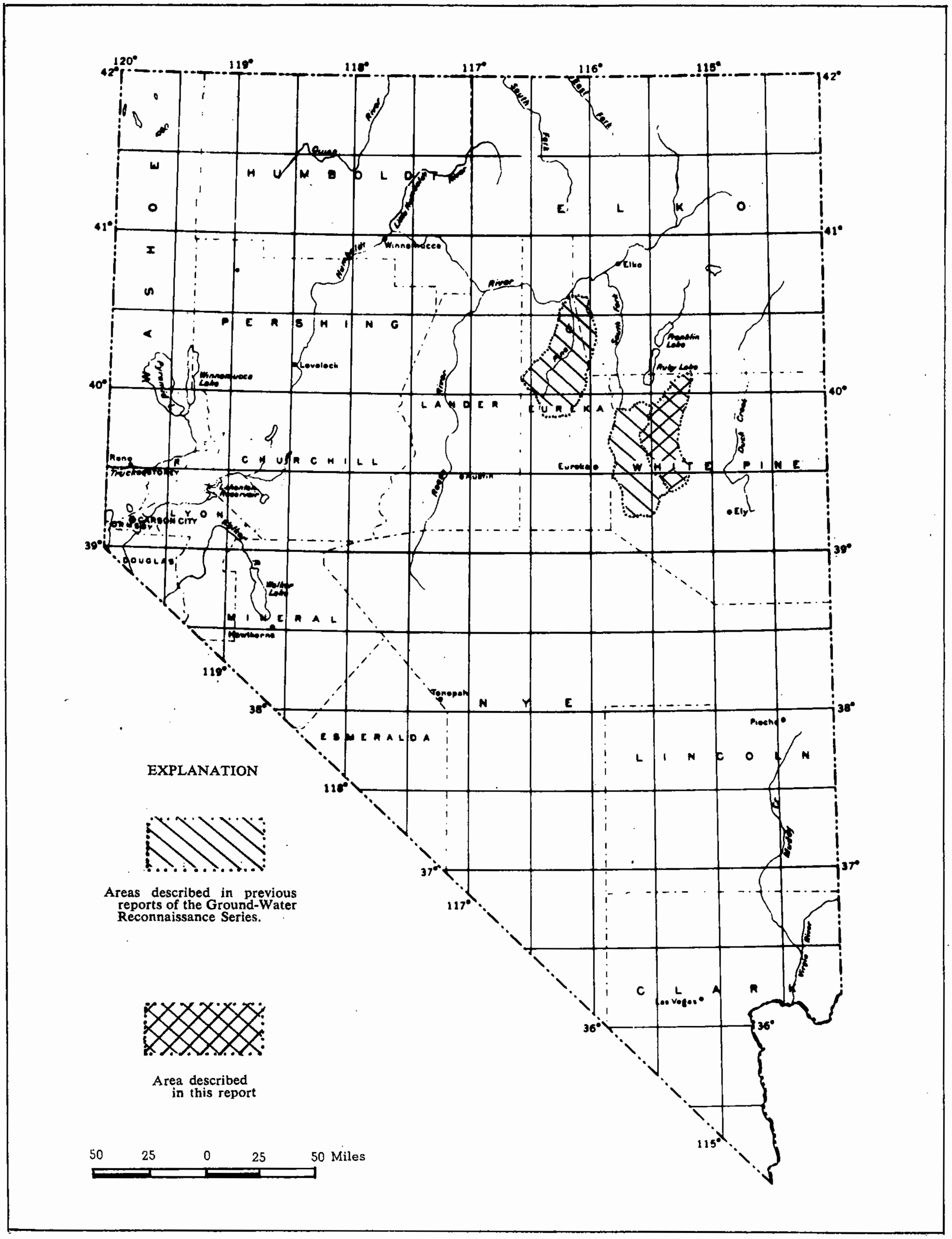

Figure 1.—Map of Nevada showing areas described in previous reports of the Ground-Water Reconnaissance Series and in this report.

The valley extends about 55 miles northward from a point near Little Antelope Summit on U. S. Highway 50. Its maximum width between drainage divides at the latitude of Buck Mountain is about 20 miles. Its average width is somewhat more than 10 miles, and its area is about 650 square miles.

The lowest part of the valley floor is about 6,050 feet above sea level. The altitude of the drainage divide ranges from about 6,500 feet in some of the passes to somewhat more than 9,000 feet at unnamed peaks in the Butte Mountains and Buck Mountain, and averages about 7,500 feet above sea level.

The central part of the valley is about 50 miles, by road, northwest of Ely, the nearest trade center, and about 110 miles south of Wells.

Principal access to Long Valley is by an improved road whose southern junction with U. S. Highway 50, about 8 miles southeast of Long Valley, is 29 miles west of Ely and 48 miles east of Eureka. This road follows the east side of the valley to about the north line of T. 21 N., then crosses the valley in a north-northwesterly direction. It continues over a low divide between the Ruby Mountains and the Maverick Springs Range into Ruby Valley where it connects with Nevada State Highway 11. State Highway 11, in turn, connects with U. S. Highway 93.

Trails or unimproved roads provide access to various parts of the valley and adjacent areas during good weather.

Long Valley is used for livestock range. Little other activity is recorded in its past history. There are no permanent residents or ranches in the valley. The nearest area of substantial mining activity was the White Pine District at Mount Hamilton, some 10 miles south of the valley. In the past there was minor mining activity in the Bald Mountain District, which is immediately west of Long Valley. Oil exploration in eastern Nevada included an oil test, drilled in the NW 1/4 NW 1/4 Sec. 32, T. 20 N., R. 60 E. which is in the southeastern part of Long Valley adjacent to the drainage divide. The test well was drilled jointly by Continental Oil and Standard Oil of California to a depth of 11,543 feet.

Climate

The climate of east-central Nevada is generally semiarid in the valleys, but in the higher parts of the mountains the climate may be sub-humid or humid. In the valleys, precipitation and humidity are generally low and summer temperatures and evaporation rates are high. Precipitation is very irregular but generally is least on the valley floors and greatest in the higher parts of the mountains. Winter precipitation occurs as snow and is moderately well distributed over several months. Summer precipitation commonly is localized as thunder-showers. The range in temperature is large, both daily and seasonally. The growing season is relatively short.

Precipitation has not been recorded within the drainage area of Long Valley. Table 1, therefore, shows the average monthly and annual precipitation according to Weather Bureau records for four stations that are within 30 miles of Long Valley. The ranges of precipitation shown in table 1 probably are indicative of the precipitation that occurs in Long Valley. Precipitation shows much variation from year to year and month to month.

The record of precipitation at McGill indicates that the annual precipitation was 8 inches or less in about 45 percent of the years of record, and was 12 inches or less in about 90 percent of the years of record.

Table 2 gives the maximum and minimum monthly and annual precipitation during the 48-year period of record at McGill. The maximum annual precipitation of 16.21 inches (about twice the average) occurred in 1918 and the minimum annual precipitation of 3.76 inches (about half the average) was recorded in 1953. The range of monthly precipitation, as shown by the table, also is substantial.

Regional precipitation during the period 1951-60 was below average as shown in table 3. During the period, precipitation was above average at Ely only in 1952, and at McGill only in 1955. Of the three stations shown in the table, only the record for Fish Creek Ranch, the station with the least average precipitation, shows precipitation to be near average for the 10-year period.

Precipitation on the floor of Long Valley probably approximates that of the Fish Creek Ranch area. Greater average precipitation is apparent in the mountains which drain to the valley floor.

The climatic summary of records of temperature at McGill prior to 1931, shows an average temperature of 44.4° F., a maximum temperature of 104° F., and a minimum temperature of -27° F. Records for the period since 1950 are within the maximum and minimum given above.

The 22-year record of temperature of the Weather Bureau station at the Ely airport shows a recorded maximum of 100° F. on July 18, 1953, and a minimum of -27° F. on January 25, 1949. The average temperature at the station is given as 45.2° F.

The 17-year record for the Fish Creek Ranch shows a maximum temperature of 98° F. during July 1948, June 1954, and July 1959. The minimum temperature recorded was -34° F., January 29, 1949.

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Table 1. Average monthly and annual precipitation, in inches, at four stations in the region of Long Valley

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
Ely 1/	0.94	0.90	1.29	1.20	1.18	0.50	0.55	0.89	0.68	0.82	0.69	0.88	10.52
Fish Creek Ranch 2/	.46	.25	.57	.56	.58	.38	.50	.47	.56	.39	.57	.56	5.85
Kimberly 3/	1.52	1.67	1.54	1.30	1.02	.67	.78	.93	.81	1.04	.85	1.16	13.29
McGill 4/	.70	.64	.77	1.02	.80	.65	.76	.74	.52	.79	.60	.70	8.69

1/ U.S. Weather Bureau station at Ely Airport. Altitude 6,257 feet. Location, Sec. 35, T. 17 N., R. 63 E. Period of Record, 22 years, 1939-60 (continuing).

2/ Altitude, 6,050 feet. Location, Sec. 10, T. 16 N., R. 53 E. Period of record, 17 years, 1944-60 (continuing).

3/ Altitude, 7,230 feet. Location, sec. 8, T. 16 N., R. 62 E. Period of record, 30 years, 1927-58.

4/ Altitude, 6,340 feet. Location, Sec. 21, T. 18 N., R. 64 E. Period of record, 48 years, 1913-60 (continuing).

Table 2. Maximum and minimum monthly and annual precipitation, in inches, at McGill for period of record.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
Maximum	4.61	2.32	2.54	2.13	3.33	3.25	3.03	2.92	2.15	2.14	1.90	1.67	16.21
Minimum	T	.02	.02	.11	.02	0	0	0	0	0	0	T	3.76

Table 3. Annual precipitation, in inches, for three climatological stations in the vicinity of Long Valley, 1951-60

Year	Ely	Fish Creek Ranch	McGill	Year	Ely	Fish Creek Ranch	McGill
1951	7.29	5.66	8.50	1956	6.36	2.77	7.95
1952	10.98	8.76	7.27	1957	9.14	e 9.77	7.67
1953	5.22	2.17	3.76	1958	7.58	e 5.66	6.57
1954	7.89	4.66	6.80	1959	5.97	e 5.49	5.67
1955	8.76	e 7.68	9.19	1960	7.89	e 4.89	6.14
			10-year average		7.71	e 5.75	6.95

e/ Estimated.

The average growing season has not been determined for Long Valley. Some idea of the probable growing season may be obtained by reference to nearby areas. Houston (1950, p. 16) gives the average growing season at McGill as 119 days (May 26 to September 22). Killing-frost conditions vary with the type of crop. Weather Bureau records beginning in 1948 in this area list freeze data rather than killing-frost dates. The dates are listed for the last spring minimum and the first fall minimum of temperatures 32° F. or below, 28° F. or below, 24° F. or below, 20° F. or below, and 16° F. or below. From these data, the number of days between the last spring minimum and first fall minimum temperatures of each group are given. Table 4 lists the number of days between the last spring minimum and the first fall minimum of the three principal temperature groups for the stations at Ely airport, Fish Creek Ranch, and McGill for the 10-year period 1951-60.

The topography of Long Valley favors the flow of heavy cold air toward the lower parts of the valley during periods of little or no wind movement. Therefore, the length of the growing season, although relatively short because of the latitude and because of the rather high altitude of the valley floor, undoubtedly varies considerably from one locality to another depending upon the pattern of flow of cold air currents. This may be illustrated, in part, by a comparison of the records of temperature at the climatological stations at Ely and McGill. The station at McGill is on the alluvial apron along the east side of Steptoe Valley. It is 250 to 300 feet above the drainage axis of the valley. The station at the Ely airport, although only about 80 feet lower than the McGill station, is near the topographic low of the valley in that latitude.

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Table 4. Freeze data for Ely, Fish Creek Ranch, and McGill climatological stations, 1951-60

Year	Number of days between temperatures of:								
	32° F. or below			28° F. or below			24° F. or below		
	Ely	Fish Creek Ranch	McGill	Ely	Fish Creek Ranch	McGill	Ely	Fish Creek Ranch	McGill
1951	91	9	123	94	81	144	124	94	192
1952	88	44	150	88	87	204	188	142	216
1953	70	3	117	90	69	---	128	89	191
1954	97	48	114	97	70	174	124	98	178
1955	7	7	116	114	82	141	143	88	183
1956	86	11	137	130	58	164	153	135	194
1957	75	28	121	96	35	136	139	121	151
1958	91	2	120	112	98	151	172	139	180
1959	53	8	120	113	79	126	130	121	130
1960	63	87	90	63	87	93	96	141	143
10-year average	72	25	121	100	75	133	140	117	176

The 10-year average number of days between temperatures of 32° F. or below, is 121 days at McGill, and 72 days at Ely airport; 28° F. or below, 133 days at McGill, and 100 days at Ely airport; and for 24° F. or below, about 176 days at McGill and 140 days at Ely airport.

Thus, the average growing season at McGill apparently averages 36 to 49 days more than at Ely airport. Similar local variations may be expected in Long Valley.

On the basis of altitude and topographic environment it would appear that the conditions controlling minimum temperature in the lower parts of Long Valley are more nearly comparable with those at Fish Creek Ranch and Ely airport than with those at McGill.

To the writer's knowledge, no experimental study has been made of the temperature, humidity, and wind distribution in the lower parts of closed or partially closed valleys in Nevada. A recommendation for a type study of this nature is made in this report in a later section on recommendations for special studies.

Physiography and Drainage

Long Valley is a closed valley in the central part of the Great Basin section of the Basin and Range province of Fenneman (1931, p. 328). It is generally elongate in a northerly direction but somewhat concave to the east.

Its south end terminates in the mountain mass formed by the convergence of the Butte and Antelope Mountains. The Butte Mountains form the eastern boundary of the valley. The western boundary of the valley is formed by the topographically connected Antelope Mountains, Buck Mountain, and contiguous parts of the Ruby Mountains and the Maverick Springs Range. Bedrock topographic highs connected by alluvial divides between the Maverick Springs Range and the Butte Mountains close the valley on the north.

The lowest part of the valley floor, in T. 21 N., R. 58 E., is about 6,050 feet above sea level. The highest points in the enclosing mountains are unnamed peaks in Buck Mountain and the Butte Mountains whose altitudes are slightly more than 9,000 feet. Thus, maximum relief in the valley is on the order of 3,000 feet.

Nearly all the crest of the Butte Mountains is more than 7,000 feet above sea level, and about 10 miles of it exceeds 8,000 feet; the average probably is about 7,500 feet.

Altitudes of the mountain crests along the west side of Long Valley are comparatively low south of Buck Mountain and average less than 7,000 feet above sea level. From Buck Mountain northward, however, the crests are considerably higher and average somewhat more than 7,500 feet. The highest point is an unnamed peak in the Buck Mountain area, 9,160 feet above sea level. (See photograph 1).

The lowest part of the valley floor is in the latitude of Buck Mountain along the east side of the valley. The gradient along the longitudinal axis of the valley rises both north and south of this area and averages about 20 feet per mile.

The cross-valley gradients away from the flat floor of the valley increase rapidly toward the mountains, and even in the lower parts of the valley approach

Table 4. Freeze data for Ely, Fish Creek Ranch, and McGill climatological stations, 1951-60

Year	Number of days between temperatures of:								
	32° F. or below			28° F. or below			24° F. or below		
	Ely	Fish Creek Ranch	McGill	Ely	Fish Creek Ranch	McGill	Ely	Fish Creek Ranch	McGill
1951	91	9	123	94	81	144	124	94	192
1952	88	44	150	88	87	204	188	142	216
1953	70	3	117	90	69	---	128	89	191
1954	97	48	114	97	70	174	124	98	178
1955	7	7	116	114	82	141	143	88	183
1956	86	11	137	130	58	164	153	135	194
1957	75	28	121	96	35	136	139	121	151
1958	91	2	120	112	98	151	172	139	180
1959	53	8	120	113	79	126	130	121	130
1960	63	87	90	63	87	93	96	141	143
10-year average	72	25	121	100	75	133	140	117	176

The 10-year average number of days between temperatures of 32° F. or below, is 121 days at McGill, and 72 days at Ely airport; 28° F. or below, 133 days at McGill, and 100 days at Ely airport; and for 24° F. or below, about 176 days at McGill and 140 days at Ely airport.

Thus, the average growing season at McGill apparently averages 36 to 49 days more than at Ely airport. Similar local variations may be expected in Long Valley.

On the basis of altitude and topographic environment it would appear that the conditions controlling minimum temperature in the lower parts of Long Valley are more nearly comparable with those at Fish Creek Ranch and Ely airport than with those at McGill.

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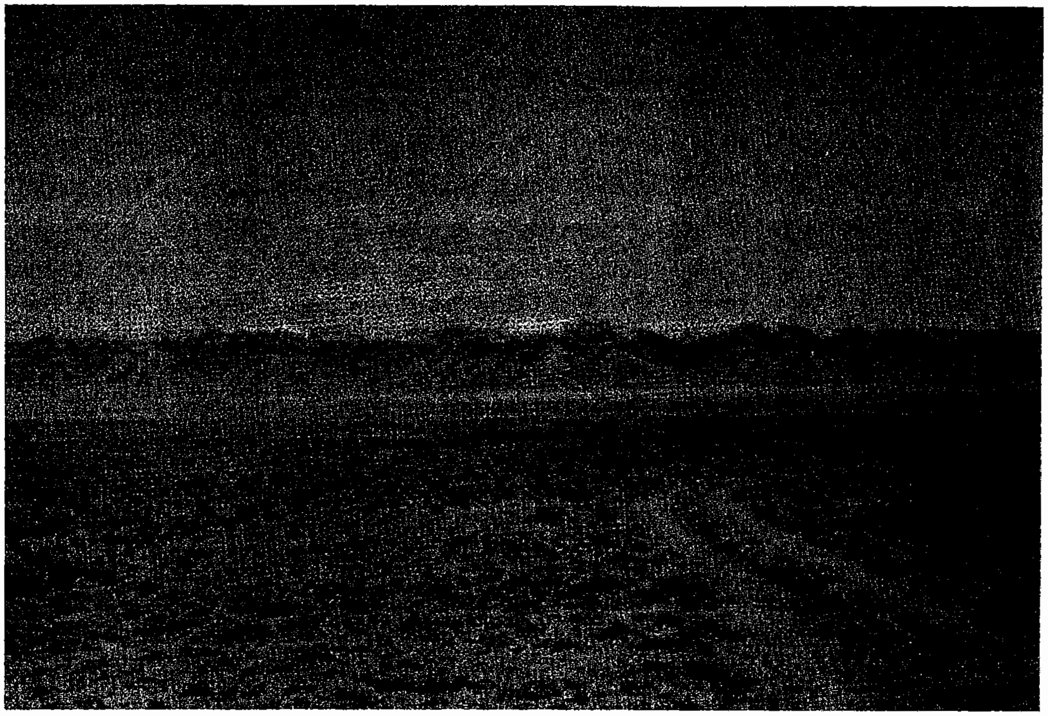
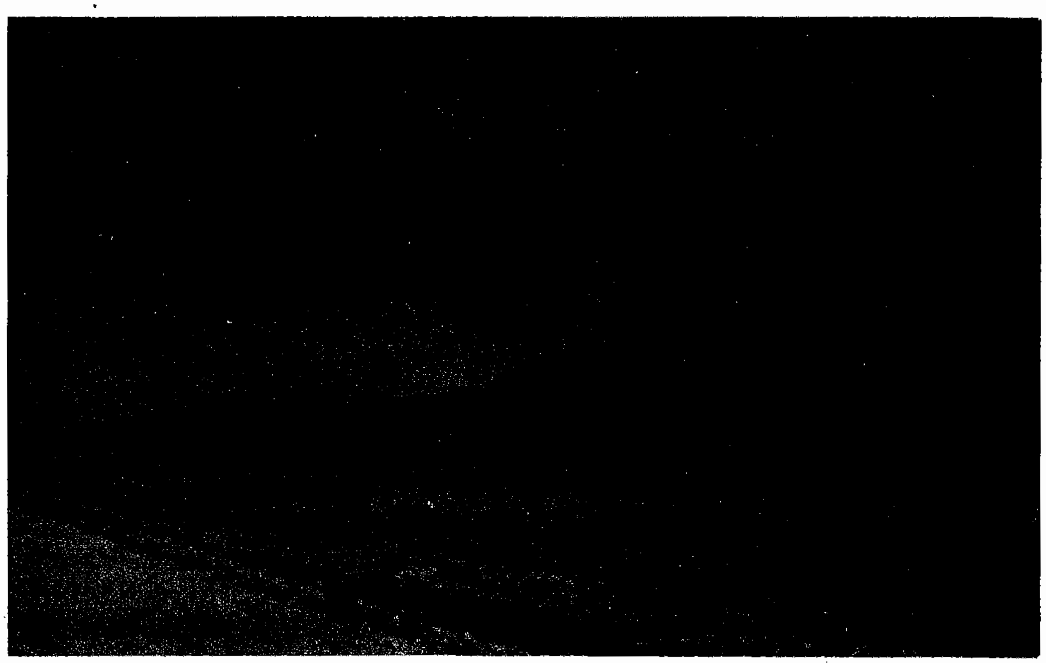


Photograph 3. View from sec. 7, T. 21 N., R. 58 E. to the east. The Butte Mountains form the skyline. The light line at the base of the mountains marks the lowest part of Long Valley. The middle distance and foreground is a part of the alluvial apron on the west side of Long Valley.



Photograph 4. View from sec. 30, T. 21 N., R. 59 E. to the north-northeast. Butte Mountains in right and left background. Alluvial apron which dips westward from the Butte Mountains is in the central part and foreground of the picture. Break-in slope formed in alluvial apron at center left edge of photo formed by wave action of a lake which occupied the valley in Pleistocene time.

GENERAL GEOLOGY

The rocks of Long Valley may be divided into two major units, the bedrock and the valley fill, based on their general relation to ground water.

The bedrock includes rocks of Paleozoic age, consisting principally of dolomite and limestone, with lesser amounts of shale and sandstone (or quartzite) and locally, at least, a thick subsurface section of evaporite deposits in the southern Butte Mountains; limited amounts of shale of Triassic age; intrusive rocks of early Tertiary age; and welded tuff or ignimbrite, basalt flows, and associated deposits of Tertiary age. These rocks crop out in the mountains surrounding Long Valley and underlie the valley fill.

Only a few drillers' logs are available to indicate some of the character of subsurface lithology and water-bearing properties of the upper part of the valley fill. However, subsurface conditions in Long Valley may be inferred on the basis of probable similarities to other valleys in eastern Nevada. It is construed that the valley fill includes deposits of Tertiary and Quaternary age. The sediments of Quaternary age are considered to be mostly clay, silt, sand, and gravel deposited under lacustrine and subaerial environments. Deposits of Tertiary age may be predominantly volcanic detritus and flows but also probably include sediments similar to those of Quaternary age. Both lacustrine and subaerial environments occurred during Tertiary time, and probably both occurred in the area now occupied by Long Valley.

Bedrock in the Mountains

The bedrock formations in the regions adjacent to Long Valley have been studied extensively, largely because of interest in the search for oil in eastern Nevada. Investigations by Rigby (1960) in the Buck Mountain-Bald Mountain area on the west side of Long Valley, and Douglass (1960) in the southern Butte Mountains on the southeast side of Long Valley are particularly pertinent to the present study. Additionally, several other papers published in the "Guidebook to the Geology of East-Central Nevada" (1960) of the Intermountain Association of Petroleum Geologists provide useful information. Other reports identifying bedrock features that might apply to Long Valley include the studies by Nolan, Merriam, and Williams (1956) in the vicinity of Eureka, and Humphrey (1960) in the White Pine Mountains adjacent to the Hamilton district.

The stratigraphic section of Paleozoic rocks described by Rigby (1960, p. 173-177) in the Buck Mountain-Bald Mountain area is about 17,000 feet thick. However, variations from one locality to another in thickness and lithology of Paleozoic formations in Nevada is well known. An example of such variations follows: In the section described by Rigby for the Buck Mountain-Bald Mountain area, the thickness of the Permian rocks is estimated to range from 1,500 to 2,000 feet, and the section includes two units of finely crystalline, earthy or silty homogeneous limestone separated by a unit of platy or thin-bedded sandstone containing some silty beds. But, in the southern Butte Mountains, 15 to 20 miles to the southeast, the Summit Springs oil test (Douglass, 1960, p. 183, and

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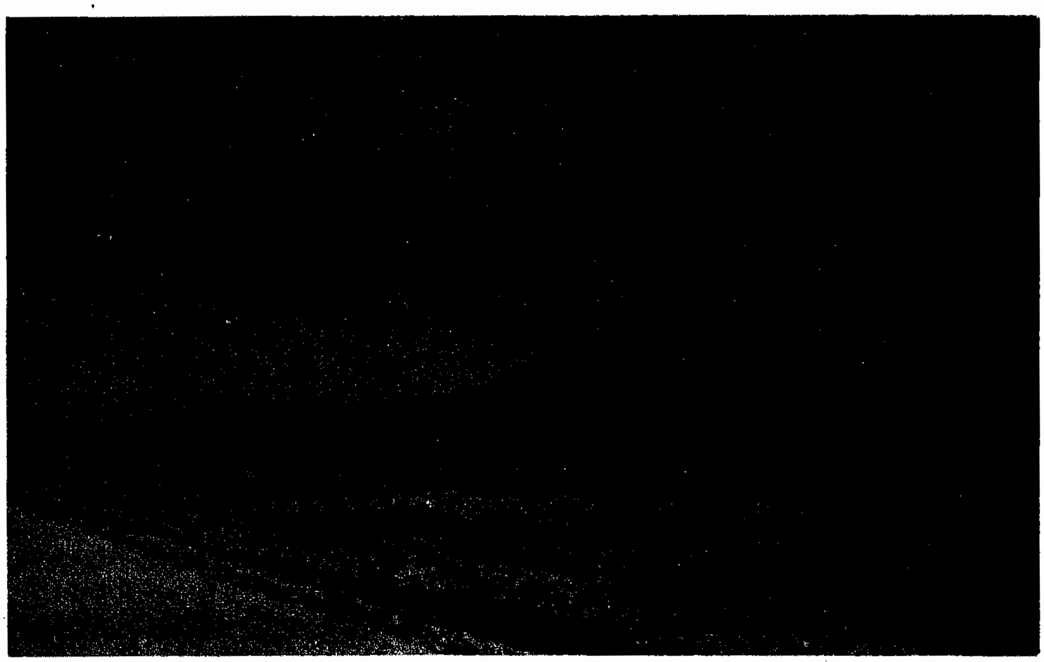

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McJannett and Clark, 1960, p. 250) encountered more than 8,500 feet of Permian rocks of which 4,370 feet was largely gypsum and anhydrite.

The following outline of the Paleozoic stratigraphy is from Rigby (1960, pp. 173-177). The formation names and age assignments are those used by Rigby and have not necessarily been adopted for use by the U. S. Geological Survey.

Age	Formation [Nomenclature of Rigby, 1960]	Lithology	Thickness (feet)
Cambrian system	Hamburg	Massive, thick-bedded limestone	80 +
	Dunderberg shale	Soft dark-green, gray, and black shale, with thin-bedded limestone	400 to 430
	Windfall formation	Catlin member--thin interbedded black limestone and shale	450 to 500
		Bullwacker member -- argillaceous thick-bedded limestone . . .	800 to 850
Ordovician system	Goodwin limestone	Limestone with minor interbedded shaly limestone and crystalline dolomite	2,100
	Antelope Valley limestone	Argillaceous, thin- to medium-bedded limestone	100 to 200
	Eureka quartzite	Vitreous light-gray quartzite with minor Interbedded siliceous sandstone. Sandstone in upper part of formation is friable, porous, less resistant than lower part of unit	234

Age	Formation /Nomenclature of Rigby, 1960/	Lithology	Thickness (feet)
Ordovician system--(continued)			
	Fish Haven dolomite	Upper-dark-gray dolomite. Lower--dark brown, cherty dolomite . . .	280
Silurian system	Laketown dolomite	Lower--compact, light- to medium-gray dolomite	30
		Middle--gray brown dolomite with minor interbedded light-gray crystalline dolomite	230
		Upper-compact, light-to medium-gray dolomite, coarser grained than lower unit	490
Devonian system	Sevy dolomite	Lower--light- to medium-gray crystalline dolomite, poor bedding . .	1,080
		Upper--finely crystalline dolomite	280
	Simonson dolomite	Lower-light- to medium-gray, very coarsely crystalline dolomite . . .	340
		Upper--interbedded light-gray aphanitic dolomite and medium dark-gray or gray-brown, crystalline dolomite . .	350
	Guilmette limestone	Obscure, irregularly bedded massive limestone	950

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Devonian system--(continued)			
Devonian Mississippian rocks	Pilot shale	Tan, yellow, yellowish-gray siltstone, occasional thin beds of limestone	400 to 500
Mississippian system	Joana limestone	Gray or brown limestone with interbedded stringers and lenses of chert . . .	100
	Chainman shale	Lower--tan or yellow-gray, silty, clay shale	155
		Middle--medium- to dark-gray limestone	100
		Upper--dark greenish-black, carbonaceous graywacke and clay shale	750
Mississippian-Pennsylvanian rocks	Diamond Peak formation	Interbedded cobble and pebble conglomerate, sandstone, shale, and limestone	1,800 to 2,000
Pennsylvanian system	Moleen formation	Alternating thick-bedded, finely crystalline, heterogeneous limestone and thin-bedded argillaceous or silty limestone	1,000 to 1,200
	Tomera formation	Chert, pebble conglomerate, limestone, and thin sandstone beds	285
Permian system	"Rib-Hill" Arcturus formations	Two units of finely crystalline, earthy or silty limestone separated by yellow or buff sandstone	1,500 to 2,000

Rocks of Tertiary age in the Buck Mountain-Bald Mountain area have been described briefly by Rigby (1960, p. 177). They include as much as 300 feet of pyroclastic rocks; largely quartz-latite ignimbrite overlain unconformably (?) by as much as 250 feet of basalt flows. Rigby also refers a quartz-monzonite stock, exposed on the south flank of Bald Mountain, to the Tertiary system.

In a study of the area around the Hamilton district a few miles south of Long Valley, Humphrey (1960, p. 41-42) described fresh-water limestone, conglomerate, and interbedded tuff which he called the Illipah formation, and referred it to Eocene time. He (Humphrey, 1960, p. 43-45) also gave the name Lake Newark formation to a unit of bedded rhyolitic tuff and pyroclastic rocks, which he considered were deposited in late Miocene or Pliocene time. This unit was overlain by basalt flows. The above sequence applied to Newark Valley, which is adjacent to and west of Long Valley.

The ignimbrite unit described by Rigby probably is related to the bedded rhyolitic tuff and pyroclastics of the Lake Newark formation of Humphrey.

Valley Fill

The upper part of the valley fill in Long Valley includes unconsolidated gravel, sand, silt, and clay deposited under subaerial and lacustrine conditions since the extrusion of the basalt flows.

The lower part of the valley fill may include tuffaceous deposits, fresh-water limestone, sandstone or moderately consolidated sand, and conglomerate or gravel of Tertiary age. It seems likely that these would be generally similar to the Illipah and Lake Newark formations of Humphrey. Based on the mode of deposition, the fine-grained tuffaceous deposits probably would be the most extensive vertically and laterally; limestone and sandstone might have extensive lateral distribution but probably only limited vertical distribution; and the gravel or conglomerate would be localized along drainageways in the marginal parts of the basin.

Geologic History

The geologic history of an area portrays the sequence of events that bear on the interpretation of the occurrence and movement of ground water. It aids in obtaining a generalized understanding of probable ground-water conditions until such time as subsurface data can be obtained to define those conditions directly.

Much additional investigation is needed to define the details of the geologic history of eastern Nevada. Problems include insufficient data on structure, stratigraphy, and precise dating of particular events. The following outline of events, therefore, is highly generalized and approximate only:

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time, local deposition of several thousand feet of gypsum and anhydrite, such as was encountered in the Summit Springs oil test in the southern Butte Mountains.

2. Uplift of Paleozoic rocks by folding and complex faulting, and widespread erosion.

3. Subsidence, in part or all, of the region, resulting in deposition of marine sediments in Triassic time.

4. Uplift of the region above sea level involving faulting and folding.

5. Erosion in the highlands, and at least local deposition of fresh-water sediments of Early Cretaceous age, such as the Newark Canyon formation in the vicinity of Eureka.

6. Emplacement of granitic rocks into older rocks, probably accompanied by folding and high-angle faulting in Late Cretaceous or early Tertiary time. Rigby (1960, p. 177) refers the quartz monzonite of Bald Mountain to the Tertiary period.

7. Deposition of fresh-water limestone, conglomerate, and interbedded tuff (Illipah formation of Humphrey) in Newark Valley. Probably a similar environment occurred in the area of Long Valley.

8. Faulting and probable folding.

9. Deposition of vitric and bedded tuff and other pyroclastic rocks in late Miocene or Pliocene time, such as the Lake Newark formation of Humphrey (1960) in the Buck Mountain-Bald Mountain area.

10. Extrusion of basaltic lava in late Tertiary time.

11. Faulting and folding, involving the basalt lavas and older rocks. Development of outlines of present valleys.

12. Erosion in mountains and concurrent deposition in floors of valleys and along drainageways. Continued intermittent faulting. Development of lakes in Pleistocene time. The lakes in Long Valley stood for varying periods of time at several different levels, forming beaches, bars, and spits, particularly between the altitudes of 6,150 and 6,250 feet above sea level.

13. Deposition of relatively thin, fine-grained sediments in temporary lakes in the lower parts of Long Valley, dune sand, and sand and gravel of limited extent along drainageways.

Water-Bearing Properties of the Rocks

Consolidated rocks of Paleozoic age are exposed in the mountains surrounding Long Valley. They consist chiefly of limestone and dolomite and contain lesser amounts of shale and sandstone or quartzite, and locally, at depth in the southern Butte Mountains include substantial thicknesses of gypsum and anhydrite.

Consolidated rocks of this type usually have a low primary permeability, because the openings in the rocks at the time of deposition were small or have since been filled. However, because the rocks have been substantially faulted, folded, weathered and otherwise altered, some of these rocks locally contain many secondary openings--mainly joints. These fractures, especially when enlarged by solution, often greatly increase the permeability of some of the limestone and dolomite. At least locally, this secondary permeability can be quite important with respect to the movement of ground water in the bedrock. Indirect information strongly suggests that secondary permeability is important in parts of Long Valley. It apparently is also important in some of the limestones in White River Valley to the south, in Newark Valley to the west, and in Ruby Valley to the north, where large springs issue from limestone.

In the mountains surrounding Long Valley, a number of small springs probably are supplied by water issuing from rocks of Paleozoic age.

Douglass (1960, p. 181), described the Joana limestone as, "* * * vugular limestone and at most surface exposures appears to have good porosity and permeability." The reference to good porosity and permeability probably was based on petroleum concepts which commonly use a lower order of permeability as being effective for movement of oil than is used for movement of water. In any case, the vugular condition observed is suggestive of conditions favorable to the movement of water. McJannett and Clark (1960, p. 250), in describing the Summit Springs oil test well (NW 1/4 NW 1/4 Sec. 32, T. 20 N., R. 60 E.), referred to fracture permeability and porosity and occasional thin zones of vuggy limestone as being in the section of Permian sedimentary rocks. They also mentioned that drill stem tests of oil or gas in the Permian section recovered only drilling fluid or fresh water. These references suggest probable circulation of ground-water, at least in the Permian section of the Paleozoic rocks.

The volcanic rocks of Tertiary age exposed in the mountains generally are above the regional zone of saturation. In the southern Butte Mountains and in the eastern and southern parts of Buck Mountains, however, several springs appear to rise near the base of the volcanic rocks. These springs probably are supplied by ground water moving through the volcanic rocks. The occurrence of the springs likely is the result of lesser permeability in the immediately underlying rocks.

Sedimentary rocks of Tertiary age generally are inferred to have a fairly low permeability and thus generally will yield only rather small supplies to wells. However, where saturated beneath the floor of Long Valley, these rocks should provide considerable ground-water storage. Local beds of sand and gravel might be expected to yield moderate to large supplies of water to properly constructed wells. Unfortunately, information on the distribution and extent of sand and gravel beds is not available.

Sand and gravel strata of Quaternary age undoubtedly were deposited near the marginal parts of the floor of Long Valley and have been reported in a few time, local deposition of several thousand feet of gypsum and anhydrite, such as was encountered in the Summit Springs oil test in the southern Butte Mountains.

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7. Deposition of fresh-water limestone, conglomerate, and interbedded tuff (Illipah formation of Humphrey) in Newark Valley. Probably a similar environment occurred in the area of Long Valley.

8. Faulting and probable folding.

9. Deposition of vitric and bedded tuff and other pyroclastic rocks in late Miocene or Pliocene time, such as the Lake Newark formation of Humphrey (1960) in the Buck Mountain-Bald Mountain area.

10. Extrusion of basaltic lava in late Tertiary time.

11. Faulting and folding, involving the basalt lavas and older rocks. Development of outlines of present valleys.

12. Erosion in mountains and concurrent deposition in floors of valleys and along drainageways. Continued intermittent faulting. Development of lakes in Pleistocene time. The lakes in Long Valley stood for varying periods of time at several different levels, forming beaches, bars, and spits, particularly between the altitudes of 6,150 and 6,250 feet above sea level.

13. Deposition of relatively thin, fine-grained sediments in temporary lakes in the lower parts of Long Valley, dune sand, and sand and gravel of limited extent along drainageways.

Water-Bearing Properties of the Rocks

Consolidated rocks of Paleozoic age are exposed in the mountains surrounding Long Valley. They consist chiefly of limestone and dolomite and contain lesser amounts of shale and sandstone or quartzite, and locally, at depth in the southern Butte Mountains include substantial thicknesses of gypsum and anhydrite.

Consolidated rocks of this type usually have a low primary permeability, because the openings in the rocks at the time of deposition were small or have since been filled. However, because the rocks have been substantially faulted, folded, weathered and otherwise altered, some of these rocks locally contain many secondary openings--mainly joints. These fractures, especially when enlarged by solution, often greatly increase the permeability of some of the limestone and dolomite. At least locally, this secondary permeability can be quite important with respect to the movement of ground water in the bedrock. Indirect information strongly suggests that secondary permeability is important in parts of Long Valley. It apparently is also important in some of the limestones in White River Valley to the south, in Newark Valley to the west, and in Ruby Valley to the north, where large springs issue from limestone.

In the mountains surrounding Long Valley, a number of small springs probably are supplied by water issuing from rocks of Paleozoic age.

Douglass (1960, p. 181), described the Joana limestone as, "* * * vugular limestone and at most surface exposures appears to have good porosity and permeability." The reference to good porosity and permeability probably was based on petroleum concepts which commonly use a lower order of permeability as being effective for movement of oil than is used for movement of water. In any case, the vugular condition observed is suggestive of conditions favorable to the movement of water. McJannett and Clark (1960, p. 250), in describing the Summit Springs oil test well (NW 1/4 NW 1/4 Sec. 32, T. 20 N., R. 60 E.), referred to fracture permeability and porosity and occasional thin zones of vuggy limestone as being in the section of Permian sedimentary rocks. They also mentioned that drill stem tests of oil or gas in the Permian section recovered only drilling fluid or fresh water. These references suggest probable circulation of ground-water, at least in the Permian section of the Paleozoic rocks.

The volcanic rocks of Tertiary age exposed in the mountains generally are above the regional zone of saturation. In the southern Butte Mountains and in the eastern and southern parts of Buck Mountains, however, several springs appear to rise near the base of the volcanic rocks. These springs probably are supplied by ground water moving through the volcanic rocks. The occurrence of the springs likely is the result of lesser permeability in the immediately underlying rocks.

Sedimentary rocks of Tertiary age generally are inferred to have a fairly low permeability and thus generally will yield only rather small supplies to wells. However, where saturated beneath the floor of Long Valley, these rocks should provide considerable ground-water storage. Local beds of sand and gravel might be expected to yield moderate to large supplies of water to properly constructed wells. Unfortunately, information on the distribution and extent of sand and gravel beds is not available.

Sand and gravel strata of Quaternary age undoubtedly were deposited near the marginal parts of the floor of Long Valley and have been reported in a few wells in the valley lowland. However, their extent and specific distribution cannot be defined without substantially more data. Where they are sufficiently thick below the zone of saturation they should transmit water readily.

GROUND-WATER APPRAISAL

General Conditions

Ground water in Long Valley is presumed to originate largely or entirely in precipitation within the drainage basin. Precipitation on the flanks of the mountains undoubtedly supplies most of the recharge to the ground-water reservoir. Precipitation on the valley floor is relatively small and probably is mostly evaporated or transpired and thus does not reach the water table. The valley fill is the principal ground-water reservoir. Ground water occurs also in bedrock, where continuity of openings permits. Small springs in the mountains, particularly in the south and west sides of the valley, are supplied from perched ground water in the bedrock.

Although ground water in the valley fill in most valleys in Nevada is considered to be the most favorable for economic development of moderate supplies, existing wells in Long Valley yield only small supplies for stock use.

The largest spring in the valley is Long Valley Slough, in Sec. 25, T. 23 N., R. 58 E., where water issues from the valley fill. Its topographic position suggests that it is a depression spring, that is, a spring formed where the land surface intersects the water table.

Recharge to the ground-water reservoir in the valley fill is derived principally from infiltration of surface runoff of the upper parts of the alluvial apron, and, also, to an unknown but perhaps considerable extent, by underflow from the consolidated bedrock of the surrounding mountains.

From the areas of recharge around the marginal parts of the valley fill, ground water moves generally toward the topographically lowest part of the valley. The configuration of the water table, the upper surface of the zone of saturation, conforms generally with the slope of the land surface but has less relief. Thus, the depths to water tend to increase toward the mountains.

In typical valleys in Nevada most of the ground water is discharged by evaporation and transpiration where the water table is at or near the land surface. Transpirati on by greasewood, rabbitbrush, and other phreatophytes, and evaporation from the soil where the water table is shallow, are the principal means of ground-water discharge. This is true, in part, in Long Valley. Ground water is discharged by evapotranspiration along the lower parts of the valley generally northward from about the middle of T. 22 N. (See pl. 1). However, in the lowland area in the eastern part of T. 21 N., R. 58 E., which is the lowest part of the valley, the depth to water is 40 to 50 feet, as indicated by water levels in several wells surrounding this area. The nearly complete absence of phreatophtes around the fringe of the lowest part of the valley further supports the concept that the depth to water is substantial in the lower part of the valley.

Figure 2 shows topographic contours of the lower part of Long Valley at the same scale as plate 1. Water-level contours of the surface of the ground wells in the valley lowland. However, their extent and specific distribution cannot be defined without substantially more data. Where they are sufficiently thick below the zone of saturation they should transmit water readily.

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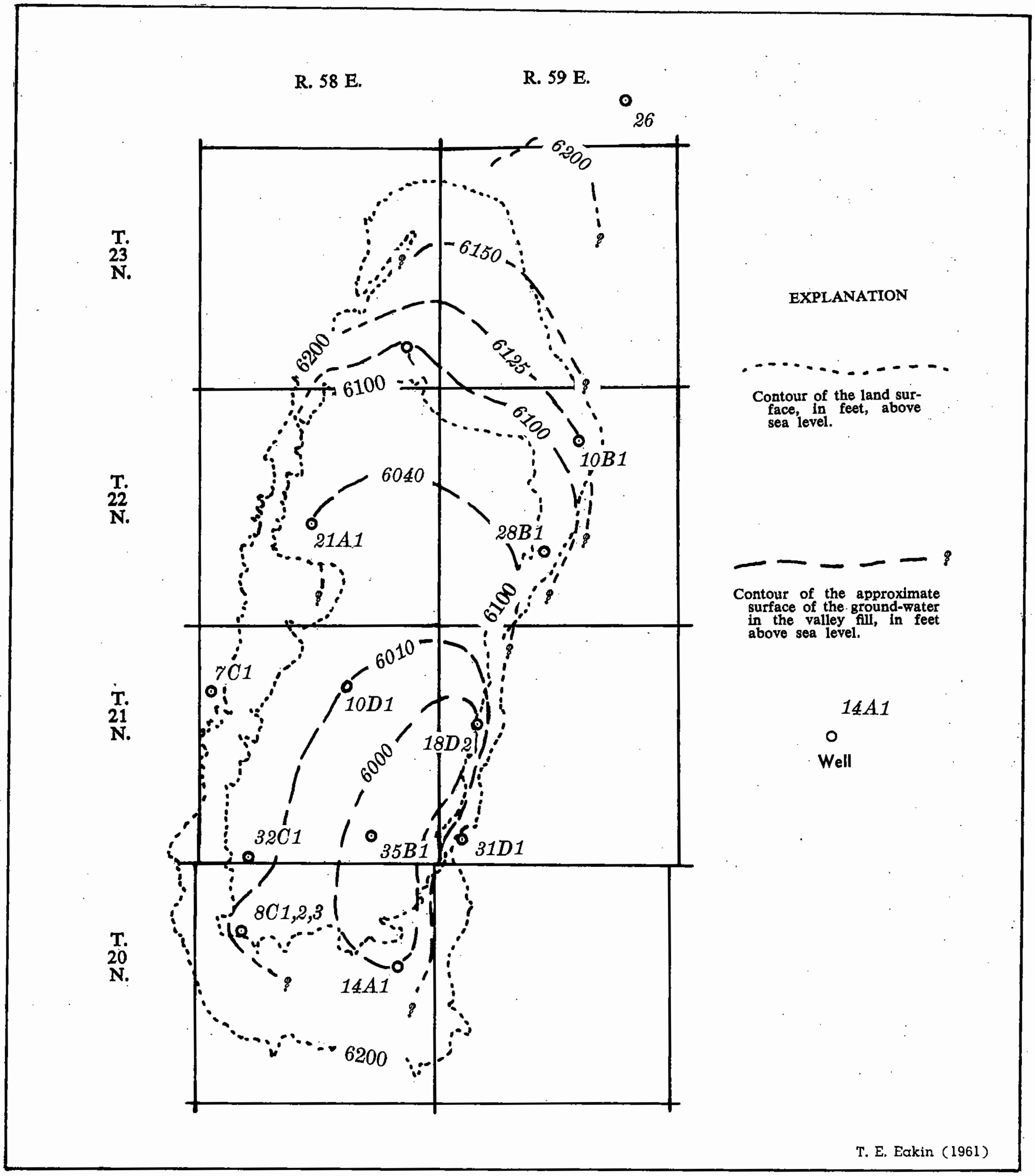


Figure 2.—Sketch of the central part of Long Valley showing contours of the land surface and of the approximate surface of ground water in the valley fill.

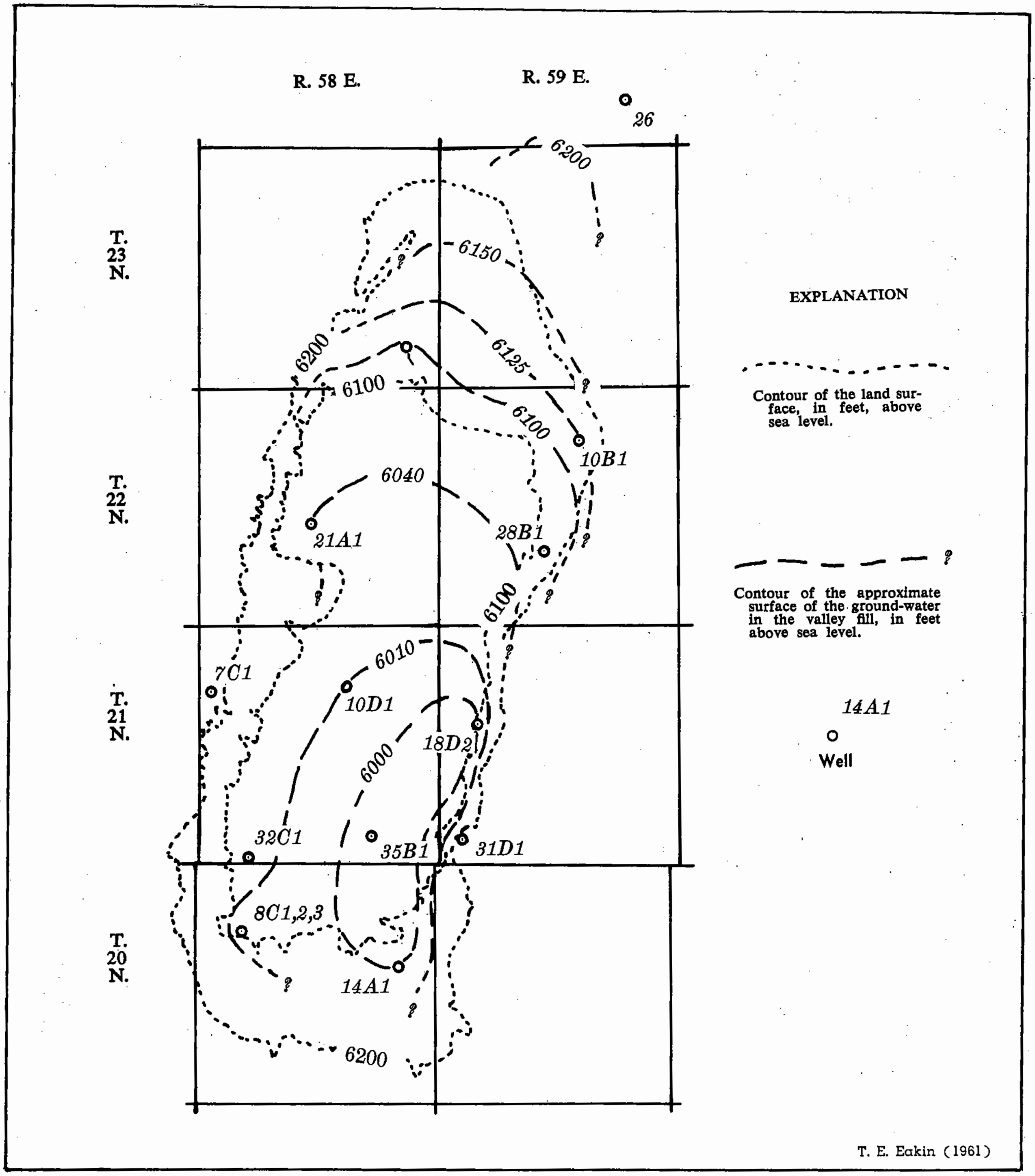
water in the valley fill are shown also for part of the area. Although the altitude control for the water-level contours is only approximate, the contours illustrate that the lowest point on the water table is in the southeastern part of T. 21 N., R. 58 E. and the northeastern part of T. 20 N., R. 58 E., and is generally about 10 miles south of the principal area of evapotranspiration.

On the basis of the available altitude controls, the 6,000-foot water-level contour is closed, but the 6,010-foot contour may not be closed on the south. Accurate vertical control would better define the altitude of the water table in the ground-water reservoir in the valley fill. Whether there is closure on the south is not known. However, the considerable depth to water below land surface in this area strongly suggests that there is lateral discharge from the ground-water reservoir contained in the valley fill. If so, it appears that this discharge could be only through the consolidated bedrock of pre-Tertiary age.

In many typically closed valleys in the Great Basin, the bedrock formations of pre-Tertiary age as a whole form a container that forms the sides and bottom of the valley fill. The valley fill can store and transmit water much more readily than the bedrock. Thus, the gross hydrologic system involves the concentration of precipitation in streams which flow toward the lowest part of the valley. The streamflow is dissipated by evaporation, transpiration, and infiltration along the route of the stream. If water is available in excess of these losses, the stream will flow to a playa area and a lake will be formed. The lake will expand or contract in response to maintaining a balance between inflow and discharge by evaporation. The simplified ground-water sequence in this hydrologic system begins with recharge to the ground-water reservoir from both streamflow and precipitation on the upper parts of the alluvial fans, or the alluvial apron. Ground-water movement is down-gradient, principally laterally, toward the area of ground-water discharge in the lowest part of the valley.

Variations in the simplified concept described above are fairly common, particularly in areas where the bedrock transmits appreciable quantities of ground water. Where the bedrock is largely composed of rocks that are soluble in moderate degree, such as the carbonate rocks of Paleozoic age in eastern Nevada, large quantities of water may be transmitted locally through solution openings in the bedrock but the gross hydrologic system may still operate as a unit within the closed valley. However, if ground water is moving out of a topographically closed basin, then the hydrologic system is no longer closed. Where the hydraulic gradient of the regional zone of saturation is not toward the lowest part of the valley along the whole of the peripheral margin of the watershed, or where there is no evidence of natural discharge within a topographically closed basin, experience has shown that appreciable amounts of ground water are being discharged to an area outside of the drainage basin of that particular valley and, therefore, that the hydrologic system is not closed.

Apparently the ground-water discharge from Long Valley through the bedrock is not great enough to drain completely the ground-water reservoir in the valley fill. The magnitude of the discharge can be computed by estimating the amount of average annual recharge to the ground-water reservoir and subtracting



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Apparently the ground-water discharge from Long Valley through the bedrock is not great enough to drain completely the ground-water reservoir in the valley fill. The magnitude of the discharge can be computed by estimating the amount of average annual recharge to the ground-water reservoir and subtracting the estimated average annual discharge by evapotranspiration from the ground-water reservoir in Long Valley. The reliability of the result, necessarily, would be a function of the accuracy of the estimated values of recharge to and discharge by evapotranspiration from the ground-water reservoir.

Meager information on water-table altitudes in the valley fill suggests that ground water is discharging into the bedrock through a line or elongate-area sink which might be located about in the eastern part of Tps. 20 and 21 N., R. 58 E.

The general direction of movement through the bedrock most logically is southward toward White River Valley. This direction of movement is suggested by the general north-south alignment of gross geologic features and structures in this region. Furthermore, in Jakes Valley, which is between Long and White River Valleys, the depth to water in the valley fill reportedly is substantial, which indirectly lends some weight to the probable movement of ground water in bedrock in this area. Farther south, in White River Valley, below Sunnyside, Maxey and Eakin (1949, p. 42) reported water-level information that strongly suggested considerable movement of ground water from valley fill into bedrock. Thus, although the data are limited and somewhat tenuous, it would appear that lateral ground-water discharge from Long Valley not only is possible but probably represents a substantial proportion of the total discharge from the ground-water reservoir. To determine by direct methods the amount of lateral ground-water discharge from Long Valley by movement into and through bedrock would be a difficult and costly study. However, such a study is proposed later in this report.

Estimated Average Annual Recharge

An estimate may be made of the average annual recharge to the ground-water reservoir as a percentage of the average annual precipitation within the valley (Eakin and others, 1951, p. 79-81). A brief description of the method follows: Zones in which the average precipitation ranges between specified limits are delineated on a map, and a percentage of the precipitation is assigned to each zone which represents the probable average recharge from the average annual precipitation on that zone. The degree of reliability of the estimate so obtained, of course is related to the degree to which the values approximate the actual precipitation, and the degree to which the assumed percentages represent the actual percentage of recharge. Neither of these factors is known precisely enough to assure a high degree of reliability for any one valley. However, the method has proved useful for reconnaissance estimates, and experience suggests that in many areas the estimates probably are relatively close to the actual long-time average annual recharge.

The precipitation map of Nevada (Hardman and Mason, 1949, p. 10)was compared with the topographic base map of plate 1. Precipitation zones were modified slightly to fit the better controlled topographic map. The division between the zones of less than 8 inches and 8 to 12 inches of precipitation was delineated at the 6,200-foot contour, between 8 to 12 inches and 12 to 15 inches at the 7,000-foot contour; and between 12 to 15 inches and more than 15 inches of precipitation at the 8, 000-foot contour.

The average precipitation assumed for the respective zones, beginning with the zone of 8 to 12 inches of precipitation, is 10 inches (0.83 feet), 13.5 inches (1.12 feet), and 16 inches (1.33 feet).

The recharge estimates as a percentage of the average precipitation for each zone is as follows: 8 to 12 inches, 1 percent; 12 to 15 inches, 7 percent; and more than 15 inches, 15 percent.

Usually the estimated recharge rate is 3 percent for the zone of 8 to 12 inches of precipitation. It was reduced to 1 percent for Long Valley because the surficial deposits of the valley lowland are relatively fine grained and the depth to water commonly is more than 40 feet. These factors tend to minimize recharge to ground water from direct precipitation, streamflow, or ponded water.

The average annual rate of precipitation of 16 inches for the zone wherein the precipitation is more than 15 inches was used on the basis that the area above 8,000 feet is small and comprises several separate units. Accordingly, it is believed that the average precipitation for the zone is not much more than the 15 inches of precipitation that is estimated to occur at the 8,000-foot altitude.

Table 5 summarizes the computation of recharge. The approximate recharge (column 5) for each zone is obtained by multiplying the figures in columns 2, 3, and 4. Thus, for the zone receiving more than 15 inches of precipitation the computed recharge is 6,000 acres x 1.33 x 0.15 (15 percent) = 1,197 (1,200 rounded) acre-feet. The average annual recharge to the ground-water reservoir in the valley fill, so estimated, is about 10,000 acre-feet.

Table 5.--Estimated average annual ground-water recharge from precipitation in Long Valley

(1) Precipitation zone (inches)	(2) Approximate area of zone (acres)	(3) Average annual precipitation (feet)	(4) Percent recharged	(5) Estimated recharge (acre-feet) (2 x 3 x 4 +100)
15+	6,000	1.33	15	1,200
12 - 15	92,000	1.12	7	7,200
8 - 12	224,000	.83	1	1,900
8-	94,000	--	--	--
	4,16,000 (650 sq. mi.)	Estimated average annual recharge (rounded)		(10,300) 10,000

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Some ground-water is discharged from Long Valley by transpiration of water-loving vegetation (phreatophytes) and by evaporation, but apparently a larger quantity is discharged from the valley fill through bedrock to areas outside of the drainage area of the valley, as discussed previously (p. 19). Because this latter quantity cannot be estimated directly, the estimate of ground-water discharge from Long Valley to areas outside of the drainage basin is obtained as the difference between the estimated ground-water recharge and the estimated ground-water discharge. Table 6 summarizes the estimated average annual ground-water discharge from Long Valley on the above basis.

Studies of Lee (1912) and White (1932) made in the Great Basin, and Young and Blaney (1942), made in southern California, form the basis for the estimate of evapotranspiration used in table 6. The rate of ground-water use was assigned on the basis of vegetative types, density, and depth to the water table.

The principal areas of phreatophytes total about 11,000 acres, and are largely in the region east and northeast of Long Valley Slough, and in parts of the axial drainage of the valley; such as Long Valley Wash in T. 23 N., R. 59 E. Elsewhere the depth to water seems to be 40 feet or more. Therefore, any phreatophytes in these areas probably obtain only negligible quantities of water from the ground-water reservoir.

Table 6.--Estimated average annual ground-water discharge from Long Valley

Method of ground-water discharge	Estimated rate of ground water use (feet per year)	Area (acres)	Approximate discharge (acre-feet per year)
Evapotranspiration: principally by mixed rabbitbrush and greasewood; depth to water 10 to 40 feet, average 25 feet	0.2	11,000	2,200
Discharge by movement into bedrock from valley fill (recharge of 10,000 acre-feet minus discharge by evapotranspiration of 2,200 acre-feet) within drainage basin			7,800
	Estimated average annual discharge		10,000

Perennial Yield

The perennial yield of a ground-water system is ultimately limited by the average annual recharge and discharge circulating into and out of the aquifer system. It is the upper limit of the amount of water than can be withdrawn for an indefinite period of time from a ground-water system without permanent depletion. The average recharge from precipitation and the average discharge by evapotranspiration, discharge to streams, and underflow from a valley are measures of the natural inflow and outflow from the ground-water system.

In an estimate of perennial yield, consideration should be given to the effects that ground-water development by wells may have on the natural circulation of the ground-water system. Development by wells may or may not induce recharge in addition to that received under natural conditions. Part of the water discharged by wells may re-enter the ground-water reservoir by downward percolation, especially if the water is used for irrigation. Ground water discharged by wells usually is offset eventually by a reduction of the natural discharge. In practice, however, it is difficult to offset fully the discharge by wells by a decrease in the natural discharge, except when the water table has been lowered to a level that eliminates both underground outflow and transpiration in the natural area of discharge. The numerous pertinent factors are so complex that, in effect, specific determination of perennial yield of a valley requires a very extensive investigation, based in part on data that can be obtained economically only after there has been substantial development of ground water for several years.

The apparent substantial ground-water discharge out of the drainage basin further complicates the evaluation of perennial yield. Pumping from wells might not salvage much of this discharge unless the wells were drilled so as to intercept the discharge or unless pumping resulted in the removal of a substantial part of the ground water in storage in the valley fill. To accomplish the required lowering of water levels in the valley fill, pumping lifts probably would have to be considerably in excess of present economic pumping lifts for irrigation. Accordingly, the preliminary minimum estimate of perennial yield is limited to the estimate of evapotranspiration from Long Valley, which is estimated to average about 2,000 acre-feet a year. The extent to which the yield could be increased above this amount would be directly proportional to the amount of underground outflow that could be salvaged. In any event, it could not exceed the estimated recharge of 10,000 acre-feet, assuming that all the natural discharge could be salvaged.

Storage

A considerable amount of ground water is stored in the valley fill in Long Valley. It is many times the volume of the average annual recharge to and discharge from the ground-water reservoir. The magnitude of this stored ground water may be obtained by the following calculation: The surface area of the valley fill lying below the 6,200-foot contour is a little more than 90,000 acres. If it is assumed that this area approximately represents the area beneath which

Estimated Average Annual Discharge

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Perennial Yield

The perennial yield of a ground-water system is ultimately limited by the average annual recharge and discharge circulating into and out of the aquifer system. It is the upper limit of the amount of water than can be withdrawn for an indefinite period of time from a ground-water system without permanent depletion. The average recharge from precipitation and the average discharge by evapotranspiration, discharge to streams, and underflow from a valley are measures of the natural inflow and outflow from the ground-water system.

In an estimate of perennial yield, consideration should be given to the effects that ground-water development by wells may have on the natural circulation of the ground-water system. Development by wells may or may not induce recharge in addition to that received under natural conditions. Part of the water discharged by wells may re-enter the ground-water reservoir by downward percolation, especially if the water is used for irrigation. Ground water discharged by wells usually is offset eventually by a reduction of the natural discharge. In practice, however, it is difficult to offset fully the discharge by wells by a decrease in the natural discharge, except when the water table has been lowered to a level that eliminates both underground outflow and transpiration in the natural area of discharge. The numerous pertinent factors are so complex that, in effect, specific determination of perennial yield of a valley requires a very extensive investigation, based in part on data that can be obtained economically only after there has been substantial development of ground water for several years.

The apparent substantial ground-water discharge out of the drainage basin further complicates the evaluation of perennial yield. Pumping from wells might not salvage much of this discharge unless the wells were drilled so as to intercept the discharge or unless pumping resulted in the removal of a substantial part of the ground water in storage in the valley fill. To accomplish the required lowering of water levels in the valley fill, pumping lifts probably would have to be considerably in excess of present economic pumping lifts for irrigation. Accordingly, the preliminary minimum estimate of perennial yield is limited to the estimate of evapotranspiration from Long Valley, which is estimated to average about 2, 000 acre-feet a year. The extent to which the yield could be increased above this amount would be directly proportional to the amount of underground outflow that could be salvaged. In any event, it could not exceed the estimated recharge of 10, 000 acre-feet, assuming that all the natural discharge could be salvaged.

Storage

A considerable amount of ground water is stored in the valley fill in Long Valley. It is many times the volume of the average annual recharge to and discharge from the ground-water reservoir. The magnitude of this stored ground water may be obtained by the following calculation: The surface area of the valley fill lying below the 6, 200-foot contour is a little more than 90, 000 acres. If it is assumed that this area approximately represents the area beneath which a reasonably thick section of the valley fill is saturated with ground water, and if a value of 10 percent is assumed as the specific yield (drainable pore space) of the saturated sediments, then about 9,000 acre-feet of water is in storage for each saturated foot of thickness of valley fill. On this basis, the amount of water in storage in the upper 100 feet of saturated valley fill would be about 90 times the natural average annual recharge to the ground-water reservoir. In addition to the water stored in the valley fill, an unknown amount of ground water is stored in the bedrock.

The principal point to be recognized is that the volume of ground water in storage provides a reserve for maintaining an adequate supply for pumping during protracted periods of drought, or for temporary periods of high demand under emergency conditions. This reserve, in effect, increases the reliability of ground water as a dependable source of supply and is an important asset in semi-arid regions where surface water supplies vary widely from year to year.

Chemical Quality

The chemical quality of the water in most ground-water systems in Nevada varies considerably from place to place. In the areas of recharge the chemical concentration of the water normally is very low. However, as the ground water moves through the system to the areas of discharge it is in contact with rock materials which have different solubilities. The extent to which the water dissolves chemical constituents from the rock materials is governed in large part by the solubility, volume, and distribution of the rock materials, the time the water is in contact with the rocks, and the temperature and pressure in the ground-water system.

No samples of water were collected for chemical analysis, and as a matter of fact there are not yet sufficient sampling points available in Long Valley to determine the general chemical character of the ground water in the various parts of the valley. On the basis of the general chemical character of water associated with limestone and dolomite rocks of Paleozoic age determined elsewhere in eastern Nevada, one might expect the ground water in Long Valley to be of calcium-magnesium bicarbonate type, at least in the marginal parts of the valley fill adjacent to the area of recharge. However, it is reported by A. K. Joy, White Pine County Agent (oral communication), that stockmen who water livestock in the valley indicate that the quality of some of the well supplies is poor. This probably refers to water from wells in the central parts of the valley. According to a note on the driller's log of well 21/59-31D1, the well was located about 3 miles east of an old well in an effort to obtain water of better chemical quality. To the writer's knowledge, no serious effort to raise crops by irrigation has been attempted in Long Valley, but should an attempt be made it is suggested that the water developed for irrigation be analyzed in order to determine its chemical suitability for the proposed crop.

Development

Ground water presently is used to a minor extent for stock supplies in Long Valley; however, the aggregate volume of water used from wells and springs is small. Data are not available to show where moderate- to large-capacity wells might be developed in the valley fill in Long Valley. However, on the basis of general geologic conditions, supplies might be obtained in parts of the middle to lower segments of the alluvial apron, especially locally along the west and north sides of the valley. It should be noted that the nonpumping, or static, water level might be more than 50 feet below land surface, which could result in excessive cost of pumping. Before extensive development is attempted, it would seem prudent to put in one or more test holes in favorable localities to determine directly whether moderate to large supplies can be obtained from wells.

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PROPOSALS FOR ADDITIONAL GROUND-WATER STUDIES

In compliance with the request of Hugh A. Shamberger, Director, Department of Conservation and Natural Resources, State of Nevada, suggestions for special studies are listed below for obtaining needed basic data for a better understanding of the factors that influence or control ground water in Long Valley and other areas in Nevada. These studies are separate from the normal areal investigations that commonly are needed after development of ground water in a given valley becomes substantial.

1. An investigation of the geologic and hydrologic factors that control the discharge of ground water from the valley fill into the bedrock and out of the drainage basin of Long Valley should be made. Although this study probably would have little economic value for Long Valley, it would have a substantial value to the State in that the knowledge and understanding gained from this valley could be applied to other areas where similar physical conditions exist.

In some areas in the central and southern part of Nevada, much or all of the ground water is discharged through bedrock from one topographically closed valley to another. In a number of valleys the valley fill is virtually drained. A study to determine the direction, rate, and quantity of ground water being discharged under these conditions within the Nevada Test Site is presently being made by the Geological Survey at the request of the Atomic Energy Commission. The situation in Long Valley provides an intermediate hydrologic environment between that of valleys where most of the ground water is drained from the valley fill into the bedrock and of hydrologically closed valleys where the entire discharge of ground water from the valley fill is by evapotranspiration where the water table is at or near the land surface.

The investigation first should be directed toward obtaining a better definition of the shape of the water table in the valley fill. If the results confirm the present hypothesis, the next phase of the study should be directed toward determination of the pattern of ground-water flow in the valley fill toward the bedrock. Subject to the results of the second phase, the final phase of the investigation would be directed toward obtaining information on the direction, rate, and quantity of movement of ground water in the bedrock of Long Valley.

The investigation should include detailed studies of geology, structure, hydrology, hydraulics, and chemical quality of water. It is evident that this study would require substantial funds, experienced personnel, and specialized equipment. The costs for the successive phases would increase, and the combined second and third phases might approach the costs of the geologic and ground-water investigations now being made at the Nevada Test Site.

2. An investigation of the microclimate of a closed valley. An investigation of this type, although not entirely related to ground-water resources, is necessary for resolving certain water-resources problems, and, additionally, it would have considerable economic value to irrigation interests. It need not be conducted in Long Valley, and, in fact, might better be undertaken in an area

where antecedent data on climate are available.

The investigation would be directed toward the study of temperature variations with respect to topography, location, orientation, and exposure, in closed or nearly closed valleys. A second objective would be a similar study on the distribution of precipitation within the same area. Together the data would be valuable in explaining variations in the length of the growing season in different parts of a closed valley. Valuable information could be obtained also on direct precipitation as a partial water supply for cropland in various topographic positions in a closed valley.

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DESIGNATION OF WELLS

The wells in this report are designated by a single numbering system. The number assigned to the well is both an identification number and a location number. It is referenced to the Mount Diablo base line and meridian established by the General Land Office.

A typical number usually consists of three units. The first unit is the township north of the Mount Diable base line. The second unit, a number separated by a slant line from the first, is the range east of the Mount Diablo meridian. The third unit, separated from the second by a dash, is the number of the section in the township. The section number is followed by a capital letter, which designates the quarter section, and, finally, a number designating the order in which the well was recorded in the quarter section. The letters A, B, C, and D designate, respectively, the northeast, northwest, southwest and southeast quarters of the section.

Thus, well number 20/58-14A1 indicates that this well was the first well recorded in the northeast quarter of sec. 14, T. 20 N., R. 58 E.

Owing to limitation of space, wells on plate 1 are identified only by the section number, quarter-section letter, and serial number. The township in which the well is located can be ascertained by the township and range numbers shown on the margin of plate 1. For example, well 20/58-14A1 is shown on plate 1 as 14A1 and is within the rectangle designated as T. 20 N., R. 58 E.

Table 7.--Records of selected wells in Long Valley

20/58-8C1. Owner, J. Goicoechea. Moore well No. 1. Dug stock well; depth 114 feet. Measuring point, top of timber curb, about 1 foot above land surface. Depth to water below measuring point, 92.2 feet, January 13, 1948.

20/58-8C2. Owner, Bureau of Land Management. Drilled stock well; diameter 6 inches, depth 170 feet, perforated 110 to 170 feet with 1/8- by 3-inch slots. Bailing test, 15 gpm (gallons per minute) with water level at 130 feet. Equipped with windmill and cylinder pump. Measuring point, top of casing, about 1 foot above land surface. Depth to water below measuring point, 91.87 feet, October 17, 1957. Replacement for 20/58-8C1. Driller's log:

Material	Thickness (feet	Depth (feet)
Top soil	12	12
Clay, some sand	9	21
Clay, with fine rock	9	30
Clay	17	47
Clay, somewhat harder	33	80
Clay	31	111
Clay, some water	37	148
Clay, harder, some sand, some water	12	160
Clay, softer, with very little sand and gravel	10	170
	Total depth	170

20/58-8C3. Owner, Bureau of Land Management (?). Drilled stock well; diameter 6 inches in 8-inch diameter surface casing. Equipped with cylinder pump and jack and gasoline engine. Measuring point, top of casing, about 1 foot above land surface. Depth to water below measuring point, 91.38 feet, February 28, 1961. Replacement (?) for well 20/58-8C2.

20/28-14A1. Owner, J. Goicoechea. Moore well no. 2 or Sunshine well. Dug and drilled stock well; casing diameter 6 inches, depth 135 feet. Equipped with cylinder pump, pump jack and gasoline engine. Measuring point, top of casing, about 2 feet above land surface. Depth to water, below measuring point, 114.56 feet, January 13, 1948, and 116.95 feet, October 17, 1957.

20/59-20(?). Owner, unknown. Abandoned dug well; depth 149 feet. Well dry.

21/58-7C1. Owner, F. Goicoechea. Juristi(?) or Shallow well. Dug stock well; depth 13 feet. Depth to water below land surface 11.0 feet, October 17, 1957.

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Material	Thickness (feet	Depth (feet)
Top soil	12	12
Clay, some sand	9	21
Clay, with fine rock	9	30
Clay	17	47
Clay, somewhat harder	33	80
Clay	31	111
Clay, some water	37	148
Clay, harder, some sand, some water	12	160
Clay, softer, with very little sand and gravel	10	170
	Total depth	170

20/58-8C3. Owner, Bureau of Land Management (?). Drilled stock well; diameter 6 inches in 8-inch diameter surface casing. Equipped with cylinder pump and jack and gasoline engine. Measuring point, top of casing, about 1 foot above land surface. Depth to water below measuring point, 91.38 feet, February 28, 1961. Replacement (?) for well 20/58-8C2.

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21/58-7C1. Owner, F. Goicoechea. Juristi(?) or Shallow well. Dug stock well; depth 13 feet. Depth to water below land surface 11.0 feet, October 17, 1957.

21/58-10D1. Owner, J. Etchegary. Long Valley well no. 1. Drilled stock well; casing diameter 6 inches, depth 120 feet, perforated 80 to 120 feet with 1/4- by 3-inch slots. Equipped with cylinder pump, pump jack, and gasoline engine. Reported depth to water, 60 feet. Driller's log:

Material	Thickness (feet)	Depth (feet)
Soil	5	5
Clay, white	75	80
Sand, water	1	81
Clay	37	118
Sand and gravel, water	2	120
	Total depth	120

21/58-32C1. Owner, J. Etchegary. Long Valley well no. 2. Dug stock well. Equipped with cylinder pump, pump jack, and gasoline engine. Measuring point, top of pump base, 1.4 feet above land surface. Depth to water below measuring point, 75.15 feet, October 17, 1957.

21/58-32C2. Owner, J. Etchegary. Drilled stock well, casing diameter 6 inches, depth 105 feet, perforated 80 to 105 feet with 1/4- to 4-inch slots. Replacement for 21/58-32C1. Driller's log:

Material	Thickness (feet)	Depth (feet)
Clay, white	50	50
Sand	2	52
Clay, white	32	84
Gravel, water	2	86
	Total depth	86

21/58-35B1. Owner, P. Elia. Dry Lake well no. 2. Unused drilled well; casing diameter 6 inches, depth 79 feet. No equipment. Measuring point, top of casing. Depth to water below measuring point, 68.39 feet, October 17, 1957.

21/59-18D1. Owner, P. Elia. Dry Lake well no. 1. Dug well replaced by 21/59-18D2.

21/59-18D2. Owner, P. Elia. Drilled stock well; casing diameter 6 inches. Equipped with jet pump and gasoline engine. Measuring point, top of casing, about 1 foot above land surface. Depth to water below measuring point, 88.0 feet, October 18, 1957.

21/59-31D1. P. Elia. Drilled stock well; casing diameter 6 inches, depth 201 feet, perforated 180 to 201 feet, with 1/8- by 4-inch slots. Reported depth to water, 170 feet.

Material	Thickness (feet)	Depth (feet)
Gravel, cemented	180	180
Gravel, water	5	185
Gravel, cemented	16	201
	Total depth	201

22/58-21A1. Owner, F. Goicoechea(?). Drilled stock well; casing diameter 6 inches, depth 125 feet, perforated 80 to 125 feet with 1/8- by 4-inch slots. Equipped with cylinder pump, pump jack, and gasoline engine. Measuring point, top of casing, 0.5 foot above land surface. Depth to water, 39.33 feet, January 13, 1948. At site of McBride well, which reportedly was dug to a depth of 100 feet in about 1930. Driller's log:

Material	Thickness (feet)	Depth (feet)
Clay, white	80	80
Sand, water	1	81
Clay, white	43	124
Sand, water	1	125
	Total depth	125

22/59-10B1. Owner, P. Elia. Smith Creek well. Drilled stock well; casing diameter 6 inches, depth 123 feet. Equipped with jet pump and gasoline engine. Measuring point, top of casing, about 1 foot above land surface. Depth to water, 23.3 feet, October 17, 1957.

22/59-28B1. Owner, P. Elia(?). Drilled stock well; casing diameter 6 inches, depth 71 feet. Equipped with jet pump and gasoline engine. Measuring point, top of collar on casing, about 1 foot above land surface. Depth to water below measuring point, 63.81 feet, October 18, 1957, and 63.98 feet, March 1, 1961.

21/58-10D1. Owner, J. Etchegary. Long Valley well no. 1. Drilled stock well; casing diameter 6 inches, depth 120 feet, perforated 80 to 120 feet with 1/4- by 3-inch slots. Equipped with cylinder pump, pump jack, and gasoline engine. Reported depth to water, 60 feet. Driller's log:

Material	Thickness (feet)	Depth (feet)
Soil	5	5
Clay, white	75	80
Sand, water	1	81
Clay	37	118
Sand and gravel, water	2	120
	Total depth	120

21/58-32C1. Owner, J. Etchegary. Long Valley well no. 2. Dug stock well. Equipped with cylinder pump, pump jack, and gasoline engine. Measuring point, top of pump base, 1.4 feet above land surface. Depth to water below measuring point, 75.15 feet, October 17, 1957.

21/58-32C2. Owner, J. Etchegary. Drilled stock well, casing diameter 6 inches, depth 105 feet, perforated 80 to 105 feet with 1/4- to 4-inch slots. Replacement for 21/58-32C1. Driller's log:

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Gravel, cemented	16	201
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22/58-21A1. Owner, F. Goicoechea(?). Drilled stock well; casing diameter 6 inches, depth 125 feet, perforated 80 to 125 feet with 1/8- by 4-inch slots. Equipped with cylinder pump, pump jack, and gasoline engine. Measuring point, top of casing, 0.5 foot above land surface. Depth to water, 39.33 feet, January 13, 1948. At site of McBride well, which reportedly was dug to a depth of 100 feet in about 1930. Driller's log:

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Clay, white	80	80
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Clay, white	43	124
Sand, water	1	125
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22/59-28B1. Owner, P. Elia(?). Drilled stock well; casing diameter 6 inches, depth 71 feet. Equipped with jet pump and gasoline engine. Measuring point, top of collar on casing, about 1 foot above land surface. Depth to water below measuring point, 63.81 feet, October 18, 1957, and 63.98 feet, March 1, 1961.

23/57-24A1. Owner, Bureau of Land Management. Mooney basin well. Drilled stock well; casing diameter 6 inches, depth 270 feet, perforated 255 to 270 feet with 1/8- by 3-inch slots. Bailing test 5 gpm with small drawdown. Equipped with cylinder pump and gasoline engine. Measuring point, top of casing. Depth to water below measuring point, 233.9 feet, October 17, 1957.

Material	Thickness (feet)	Depth (feet)
Top soil and boulders	6	6
Clay, some rock and gravel	40	46
Clay, some gravel	84	130
Clay, more gravel	35	165
Clay, more rock	30	195
Gravel and sand, little clay	35	230
Gravel, little clay, water	15	245
Gravel and coarse sand, water	25	270
	Total depth	270

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23/57-24A1. Owner, Bureau of Land Management. Mooney basin well. Drilled stock well; casing diameter 6 inches, depth 270 feet, perforated 255 to 270 feet with 1/8- by 3-inch slots. Bailing test 5 gpm with small drawdown. Equipped with cylinder pump and gasoline engine. Measuring point, top of casing. Depth to water below measuring point, 233.9 feet, October 17, 1957.

Material	Thickness (feet)	Depth (feet)
Top soil and boulders	6	6
Clay, some rock and gravel	40	46
Clay, some gravel	84	130
Clay, more gravel	35	165
Clay, more rock	30	195
Gravel and sand, little clay	35	230
Gravel, little clay, water	15	245
Gravel and coarse sand, water	25	270
	Total depth	270

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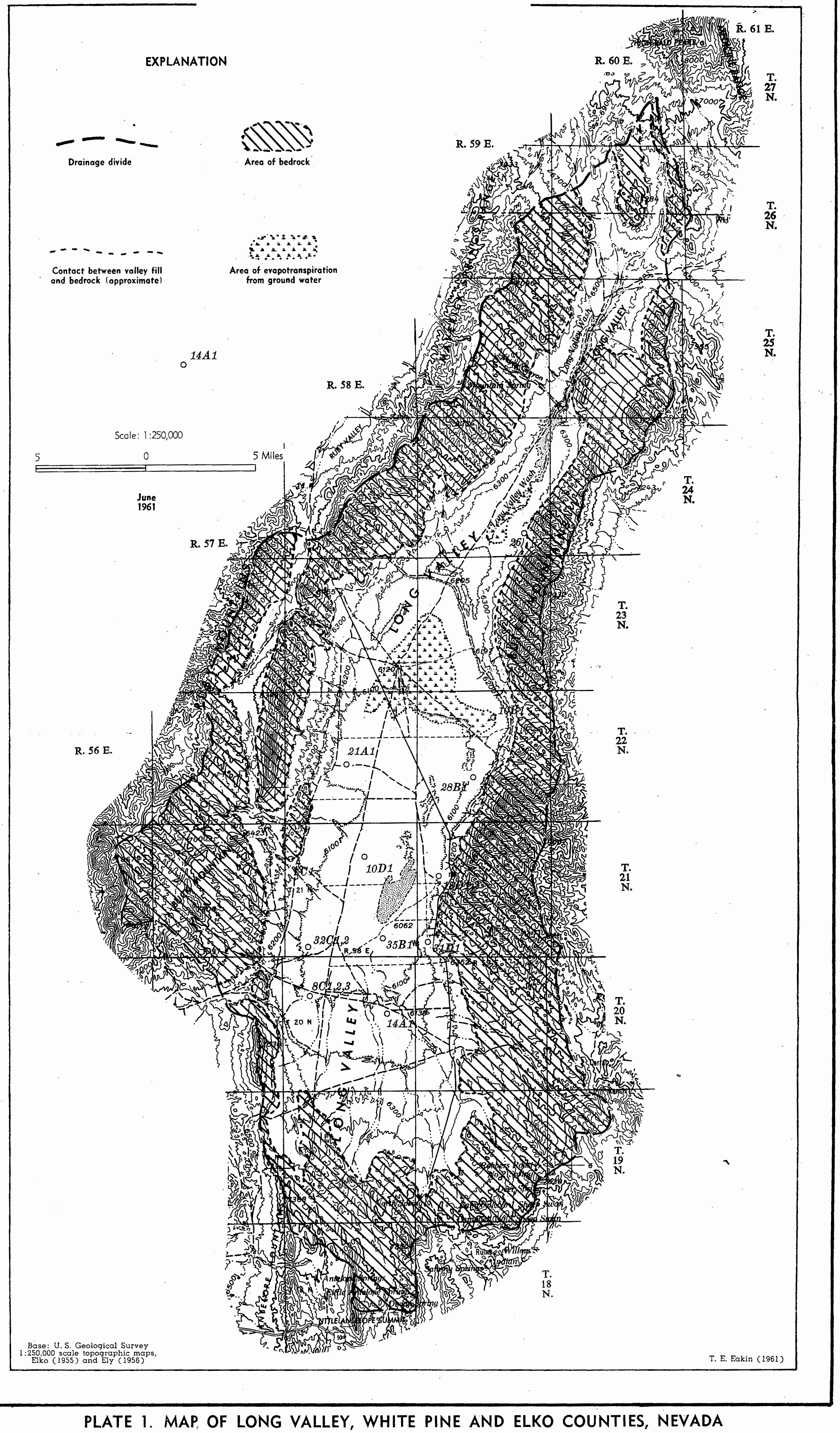

PLATE 1. MAP OF LONG VALLEY, WHITE PINE AND ELKO COUNTIES, NEVADA

SHOWING AREAS OF BEDROCK, VALLEY FILL, AND EVAPOTRANSPIRATION, AND LOCATION OF WELLS